ALTA 2023 27
30 April - 6 May | Perth, Australia

ION FLUX FLOW REGIMES OF ELECTROKINETIC TRANSPORT IN LOW PERMEABILITY POROUS MEDIA

By

[1]Kunning Tang, [2]Zhenkai Bo, [3] Zhe Li, [1]Ying Da Wang, [4]James McClure, [5]Hongli Su,
[1]Peyman~Mostaghimi, [1]Ryan Armstrong,

[1]Resources Engineering, University of New South Wales, Australia
[2]Centre for Natural Gas, University of Queensland, ,Australia
[3]Research School of Physics, The Australian National University, Australia
[2]National Security Institute, Virginia Tech, USA
[3]Institute of Frontier Materials, Deakin University, Australia

Presenter and Corresponding Author

Kunning Tang

ABSTRACT

Electrokinetic in-situ recovery is an alternative to conventional mining, relying on the application of an electric potential to enhance the subsurface flow of ions. Understanding the pore-scale ion transport under advection-diffusion-electromigration is essential for petrophysical properties estimation and flow behaviour characterization. The governing physics of the coupled transport are electromigration under electric potential, diffusion with concentration gradient, and advection due to hydraulic pressure and electroosmosis, which depend on the electric potential gradient, mineral occurrence, domain morphology (tortuosity and porosity, grain size and distribution, etc.) and electrolyte properties (local pH distribution and lixiviant type and concentration, etc.).

The governing model includes three coupled equations: (1) Poisson equation, (2) Nernst--Planck equation, and (3) Navier--Stokes equation. These equations were solved using the lattice Boltzmann method within X-ray computed microtomography images. To understand the coupled ion flow behaviour, we perform the simulation on a simple capillary tube model, a 2-dimentional heterogenous porous media, and a 3D real rock image with different corresponding length. Two dimentionless numbers (1) Peclet number; (2) a new defined Electrokinetic number are used to define the ion flow regime. The results in all three models show that 4 ion flow patterns are exist, which are (1) large channelling; (2) Uniform flow; (3) Small channelling; (4) Non flow.

With regarding to in situ recovery of minerals, with only hydraulic pressure, large channelling ion flow pattern exists where the ion prefer entering the high permeable region and cannot flow through low permeable region, which reduces the mineral extraction. However, by applying electric potential and adjusting the hydraulic pressure, the small channelling can be created, where ion prefer entering the low permeable region. The proposed study provides the fundamental understanding of the ion flow under advection-diffusion-electromigration. The result provides a potential way to control the ion flow.

Keywords: Flow regime; Advection-Diffusion-Electromigration; X-ray micro-computed tomography; Lattice-Boltzmann-Poisson Methods; ISR